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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/988,685	11/20/2001	Yoshimi Shioya		9020

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EXAMINER

HOGANS, DAVID L

ART UNIT	PAPER NUMBER
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2813

DATE MAILED: 04/05/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/988,685

Applicant(s)

SHIOYA ET AL.

Examiner

David L. Hogans

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 23 December 2003.
2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 29-47 is/are pending in the application.
4a) Of the above claim(s) 38-46 is/are withdrawn from consideration.
5) ☐ Claim(s) _____ is/are allowed.
6) ☒ Claim(s) 29-37 and 47 is/are rejected.
7) ☐ Claim(s) _____ is/are objected to.
8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
10) ☒ The drawing(s) filed on 20 November 2001 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☒ All b) ☐ Some * c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____

DETAILED ACTION

This Office Action is in response to the Amendment filed on December 23, 2003.

Election/Restrictions

Newly submitted claims 38-46 are directed to an invention that is independent or distinct from the invention originally claimed for the following reasons:

Claims 38-46 are drawn to a method of forming various silicon containing insulating layers comprised by specific chemical vapor deposition reaction gas compositions.

Since applicant has received an action on the merits for the originally presented invention, this invention has been constructively elected by original presentation for prosecution on the merits. Accordingly, claims 38-46 have been withdrawn from consideration as being directed to a non-elected invention. See 37 CFR 1.142(b) and MPEP § 821.03.

Status of Claims

Claims 1-28 are cancelled. Claims 29-47 are pending. Claims 38-46 are withdrawn.

Claim Rejections - 35 USC § 112

1. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

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2. Claims 29-37 and 47 are rejected under 35 U.S.C. 112, second paragraph, as failing to set forth the subject matter which applicant(s) regard as their invention.

Evidence that claims 29-37 and 47 fail(s) to correspond in scope with that which applicant(s) regard as the invention can be found in Applicant's Arguments filed December 23, 2003. In that paper, applicant has stated

"By the present amendments, all claims are now limited to those preferred embodiments employing a hydrocarbon in the process gas from which the plasma is formed and applied to the surface of the copper wiring layer to convert a surface portion of that layer to a copper diffusion preventing layer. As explained at page 12, lines 2-6 of applicants' original specification these embodiments offer the advantage that "a thin film of hydrocarbon is formed on the copper wiring layer, and the copper wiring can be difficult to be etched in later steps by the thin film of hydrocarbon."

and this statement indicates that the invention is different from what is defined in the claim(s) because Claim 29 refers to nitridation and not the formation of a hydrocarbon layer. Specifically, page 18 lines 1-7 of Applicant's substitute specification states that "[t]he inventors speculate that the surface portion of the copper wiring layer 110 is nitrided by the plasma process and thus a thin film of copper nitride is formed from the surface portion, and this film serves as a copper diffusion preventing layer." Therefore, the Examiner is uncertain as to the scope of the invention. Is the invention the formation of a hydrocarbon layer or the formation of a copper nitride layer (i.e. – nitridation)? Furthermore, the Examiner notes that the substitute specification

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submitted on December 2, 2002, states the following at page 11 lines 6-8: "a thin film made of C_xH_y is formed on the surface of the copper wiring layer 110 and it is believed that the copper wiring layer 110 is rendered difficult to etch in later steps by this thin film."

3. Claims 32-37 and 47 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 32 line 4 states "insulating layer on the copper wiring layer". The Examiner is uncertain as to how the insulating layer is "on" the copper wiring layer because the specification at page 18 lines 1-7 discloses that a film of copper nitride is formed over the copper layer by the plasma process before the insulating layer of Claim 32 is formed. Furthermore, the Examiner notes that according to Merriam-Webster's Collegiate Dictionary (2001), Tenth Edition, "on" is defined as a function word used to indicate position in contact with and supported by the top surface of. Therefore, the insulating layer of Claim 32 cannot be formed "on" the copper wiring layer because it is in contact with the copper nitride layer formed by the plasma process and not the copper wiring layer.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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5. Claims 29, 30, 32 and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over 6,410,462 to Yang et al. in view of 6,383,925 to Ngo et al.

Claim 29

Yang et al. teaches converting into a plasma a process gas containing N_2O and a hydrocarbon C_xH_y ; and converting a surface portion into a copper diffusion preventing layer by exposing a surface of the copper wiring layer to the process gas plasma. See columns 3-7 lines 45-50 and Figure 1

Yang et al. fails to explicitly teach nitriding a surface portion of the copper wiring layer. The Examiner does note that Yang et al. does teach similar process conditions for the plasma operation, such as, a high frequency power of 13.56 MHz and the application of a low frequency power source. See columns 3-7 lines 45-50 and Figure 1

However, Ngo et al., in columns 3-6 lines 10-57 and Figures 2-4, teaches wherein a nitrogen plasma forms a thin transition layer or bridge between a subsequently formed barrier layer and the copper surface. Once again, the Examiner notes that the temperature, wattage, pressure, duration and flow rates employed by Ngo et al. during the nitrogen nitridation step are similar to the ones disclosed by the Applicant on page 10 and Table 1 of the specification. Therefore, similar process conditions must produce similar results (i.e. – nitridation and copper diffusion prevention).

It would have been obvious to one of ordinary skill in the art to modify Yang et al. by incorporating the nitridation of a surface portion of a copper wiring layer, as taught by Ngo et al., to improve adhesion between a subsequently formed barrier layer and the copper surface.

Claim 30

Incorporating all arguments of Claim 29 and noting that Ngo et al. teaches wherein N_2 is added to a process gas that nitrides a copper surface. See columns 3-6 lines 10-57 and Figures 2-4

Claim 32

Incorporating all arguments of Claim 29 and noting that Ngo et al. teaches forming a silicon containing insulating film (40) on the copper layer after nitridation. See columns 4-6 lines 10-65.

Additionally, noting that Yang et al. forms a silicon containing insulating film on the copper layer after nitridation. See columns 3-7 lines 45-50 and Figure 1

Claim 36

Incorporating all arguments of Claims 29 and 32 and noting that Yang et al. (see columns 3-7 lines 45-50 and figure 1) and Ngo et al. (see columns 3-6 lines 10-57 and

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figures 2-4) teach wherein the silicon-containing insulating layer is selected from the group consisting of a SiOCH layer, a SiCH layer, a SiO layer, a SiN layer, a SiONCH layer, and a SiCNH layer.

6. Claim 31 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,410,462 to Yang et al. in view of 6,383,925 to Ngo et al. in view of 6,165,894 to Pramanick et al.

Incorporating all arguments of Claim 29 and noting that Yang et al. and Ngo et al. fail to explicitly teach before converting the process gas into the plasma, exposing the surface of the copper wiring layer to a NH_3 plasma to remove surface oxide from the copper wiring layer. The Examiner notes that Ngo et al. employs NH_3 with nitrogen when performing the formation of the transition layer.

However, Pramanick et al., in column 5 lines 45-55, teaches wherein a NH_3 plasma treatment is performed to a copper wiring layer before a capping layer is deposited.

It would have been obvious to one of ordinary skill in the art to modify Yang et al. and Ngo et al. by incorporating an ammonia pretreatment of copper, as taught by Pramanick et al., to remove or reduce the thin copper oxide formed during CMP.

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7. Claim 33 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,410,462 to Yang et al. in view of 6,383,925 to Ngo et al. in view of 6,150,270 to Matsuda et al.

Incorporating all arguments of Claims 29 and 32 and noting that Yang et al. and Ngo et al. fail to explicitly teach converting into a second plasma a process gas containing at least one of NH_3 , N_2 , and N_2O and exposing the silicon-containing insulating layer to the second process gas plasma. Although the Examiner notes that Yang et al. deposits a silicon containing layer with a N_2O plasma (see columns 3-7 lines 45-50) and Ngo et al. deposits a silicon containing layer with a N_2 plasma (see columns 3-6 lines 10-57).

However, Matsuda et al., in column 4 lines 52-65, teaches exposing a silicon film to a nitrogen plasma. Furthermore, Matsuda et al. teaches that the nitrogen plasma nitrides the silicon film into a silicon nitride film.

It would have been obvious to one of ordinary skill in the art to modify Yang et al. and Ngo et al. by incorporating the exposure of a silicon film to a nitrogen plasma, as taught by Matsuda et al., to nitride the silicon film into a film that functions effectively as a barrier layer for preventing oxidation and copper diffusion.

8. Claim 34 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,410,462 to Yang et al. in view of 6,383,925 to Ngo et al. in view of 6,174,810 to Islam et al.

Incorporating all arguments of Claims 29 and 32 and noting that Yang et al. and Ngo et al. fail to explicitly teach forming an insulating layer over the silicon containing insulating film, forming a via hole through the insulating layer and the silicon containing insulating layer, burying a plug connected to the copper layer and forming an upper wiring layer connected to the plug. The Examiner notes that Ngo et al. teaches forming a damascence structure with a plug formed in a via hole in an insulating layer. See column 5 lines 02-20

However, Islam et al. in columns 5-7 lines 10-26 and Figures 1-7, teaches forming an insulating layer over the silicon containing insulating film, forming a via hole through the insulating layer and the silicon containing insulating layer, burying a plug connected to the exposed copper layer and forming an upper wiring layer connected to the plug. Furthermore, Islam et al. teaches that one would do this to form a copper interconnect structure.

It would have been obvious to one of ordinary skill in the art to modify Yang et al. and Ngo et al. by incorporating an insulating layer formed over the silicon containing insulating film, forming a via hole through the insulating layer and the silicon containing

insulating layer, burying a plug connected to the exposed copper layer and forming an upper wiring layer connected to the plug, as taught by Islam et al., to form a copper interconnect structure.

9. Claim 35 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,410,462 to Yang et al. in view of 6,383,925 to Ngo et al. in view of 6,174,810 to Islam et al. in view of 6,277,733 to Smith.

Incorporating all arguments of Claims 29, 32 and 34 and noting that Yang et al., Ngo et al. and Islam et al. fail to explicitly teach wherein the insulating film is formed by FSG or porous silicon dioxide.

However, Smith, in column 3 lines 13-30, teaches a dielectric layer formed of FSG that is formed over a silicon containing barrier layer, wherein both layers are etched to expose a copper surface. Furthermore, Smith, teaches that FSG is a good dielectric layer because it has a low dielectric constant.

It would have been obvious to one of ordinary skill in the art to modify Yang et al., Ngo et al. and Islam et al. by incorporating a dielectric layer formed of FSG that is formed over a silicon containing barrier layer, wherein both layers are etched to expose a copper surface, as taught by Smith, to form a dielectric layer that has a low dielectric constant.

Double Patenting

10. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. See *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and, *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 CFR 1.130(b).

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

11. Claims 29-37 and 47 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-4 of U.S. Patent No. 6,479,408 to Shioya et al. in view of 6,383,925 to Ngo et al.

Shioya et al. teaches converting into a plasma a process gas containing N₂O and a hydrocarbon C_xH_y; and converting a surface portion into a copper diffusion preventing layer by exposing a surface of the copper wiring layer to the process gas plasma.

Shioya et al. fails to explicitly teach wherein a surface portion of the copper layer is nitrided.

However, Ngo et al., in columns 3-6 lines 10-57 and Figures 2-4, teaches wherein a nitrogen plasma forms a thin transition layer or bridge between a subsequently formed barrier layer and the copper surface. Additionally, the Examiner notes that the temperature, wattage, pressure, duration and flow rates employed by Ngo et al. during the nitrogen nitridation step are similar to the ones disclosed by the Applicant on page 10 and Table 1 of the specification. Therefore, similar process conditions must produce similar results (i.e. – nitridation and copper diffusion prevention).

It would have been obvious to one of ordinary skill in the art to modify Shioya et al. by incorporating the nitridation of a surface portion of a copper wiring layer, as taught by Ngo et al., to improve adhesion between a subsequently formed barrier layer and the copper surface.

Response to Arguments

12. Applicant's arguments with respect to claims 29-47 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

13. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to David L. Hogans whose telephone number is (571) 272-1691. The examiner can normally be reached on M-F (7:30-4:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead Jr. can be reached on (571) 272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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Tuan H. Nguyen
Primary Examiner